

# LSA Enabling Technologies, Demos and Trials

Prakash Moorut and Joseph Schuler

May 8, 2014

## Agenda

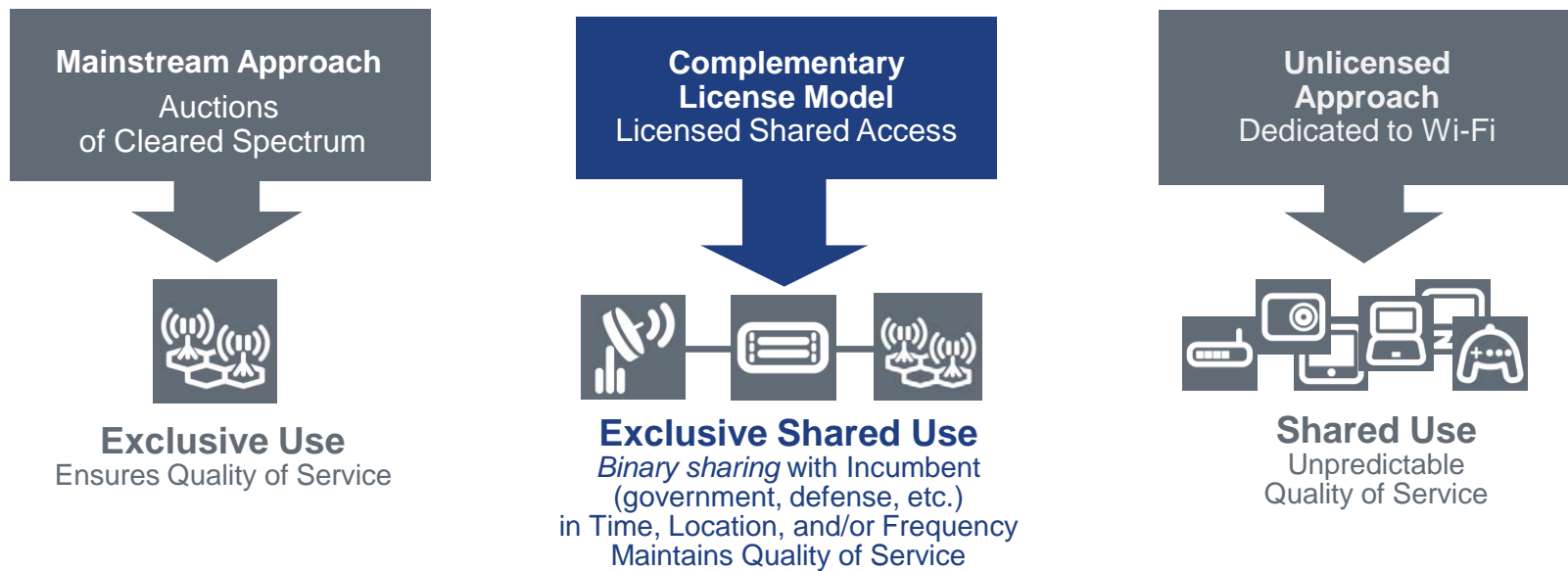
**Overview of Licensed Shared Access (LSA)**

**Demos and trials**

**Conclusions**

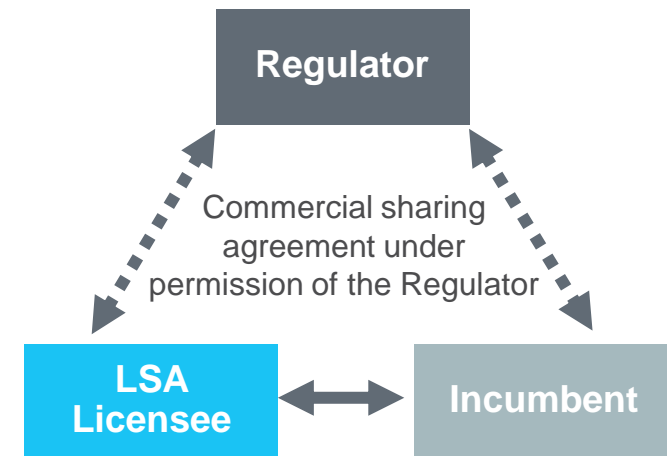
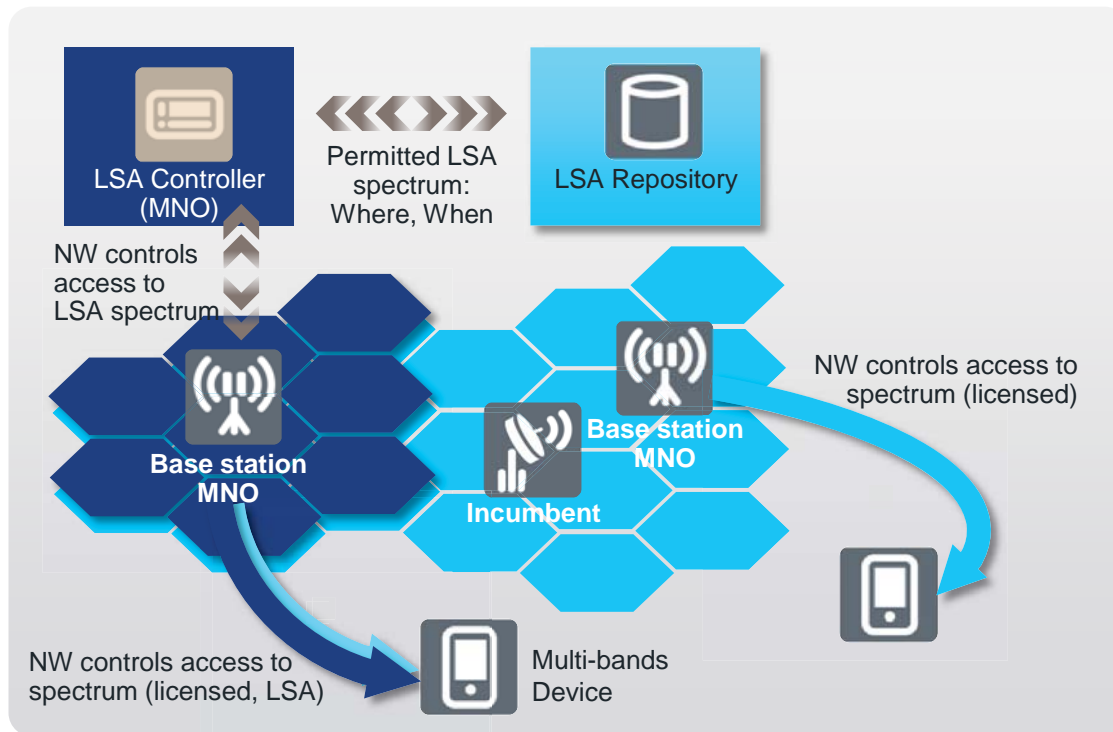
## A new way of licensing spectrum

### Licensed Shared Access (LSA)



## Harmonization and Global Standards Drive Economies of Scale

## Licensed Shared Access Concept



## ASA / LSA Spectrum Sharing Objectives

LSA when dedicated spectrum is not available

### Shared Spectrum Opportunities

- Quality of Service is key
- 2.3 GHz in Europe
- AWS-3 + 3.5 GHz in U.S.

### Satisfy Incumbent & Operator Needs

- Incumbent use when needed
- Minimize exclusion zones
- Maintain end user experience

### Evolutionary Approach

- Start with LTE standards
- Start with existing products
- Evolve as needed

## Nokia Spectrum Sharing Efforts to Date

### Industry Environment

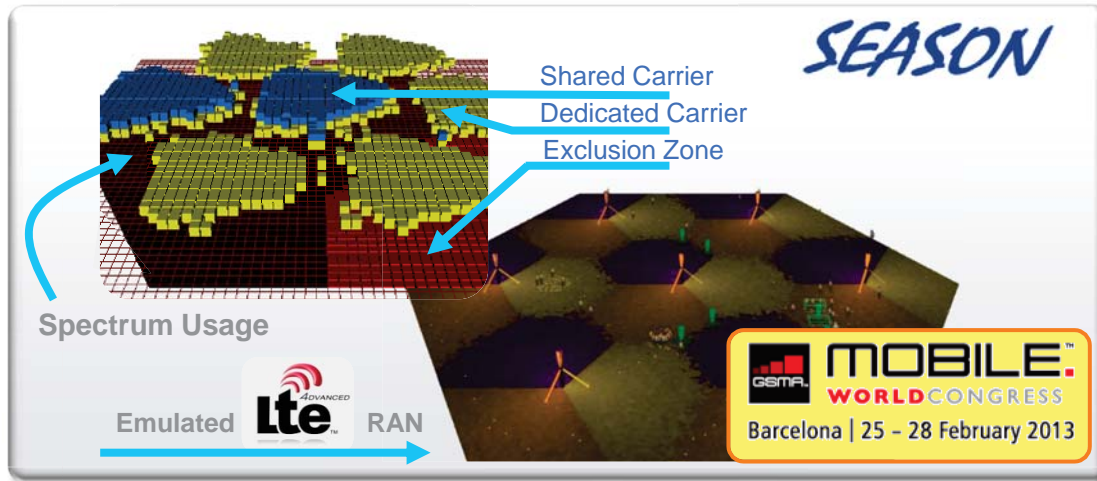
- Regulatory framework in U.S. and Europe
- ETSI Standards
- Operator engagements

### Technology Demonstration

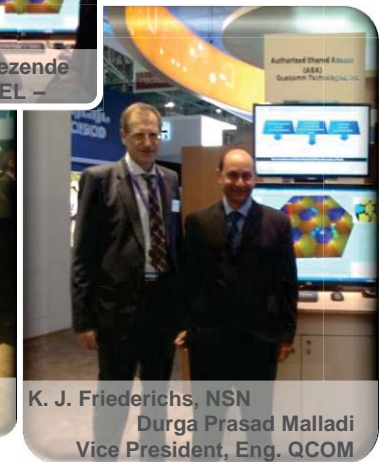
- Laboratory demo of existing enablers
- System level behavioral modeling
- Finland outdoor field trial  
(Government funded with partners)

## NSN/Qualcomm LSA demonstration at MWC-2013

- Joint demo with **QUALCOMM**
- Huge attention from vendors, telecom operators, device and chip set industry, regulatory bodies e.g. ITU-R and CEPT, national regulators e.g. Anatel, European Commission RSPG, representatives of ministries from several countries and press.
- In total > 200 visitors over 3½ days.



**GSM MOBILE WORLD CONGRESS**  
Barcelona | 25 - 28 February 2013



### SEASON tool

developed in  
cooperation with ..

noimor  
research

within framework of  
research project ..

CoMoRa  
COGNITIVE MOBILE RADIO

partially  
funded by ..

Bundesministerium  
für Bildung  
und Forschung

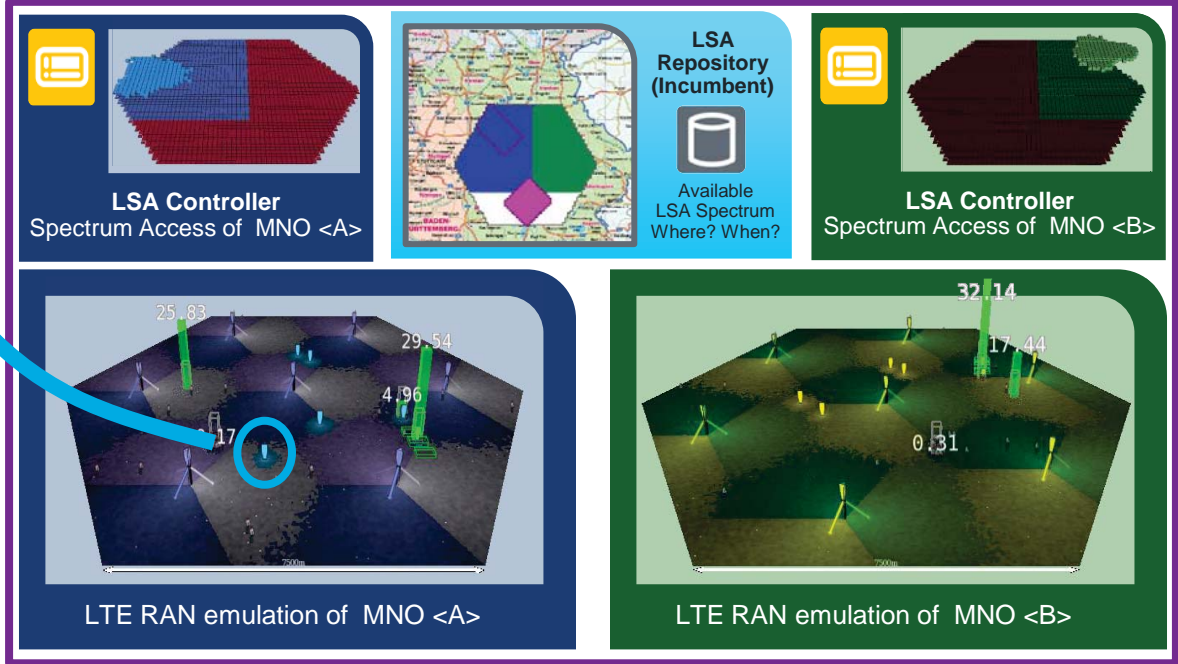
**NOKIA**

# NSN/Qualcomm Joint LSA Demonstration at MWC-2014

## Hardware Setup



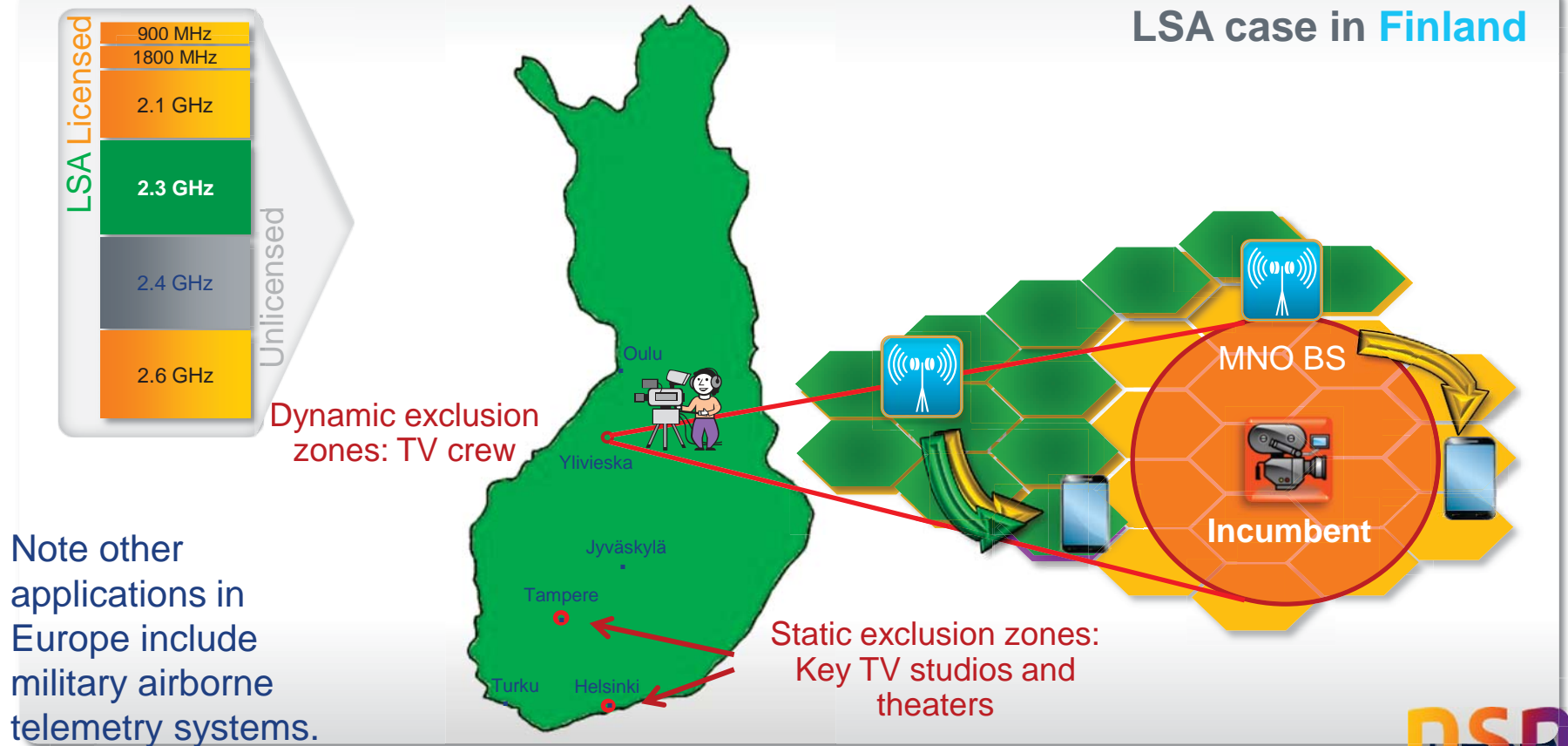
## LSA Network and Traffic Simulation (NSN enabled)



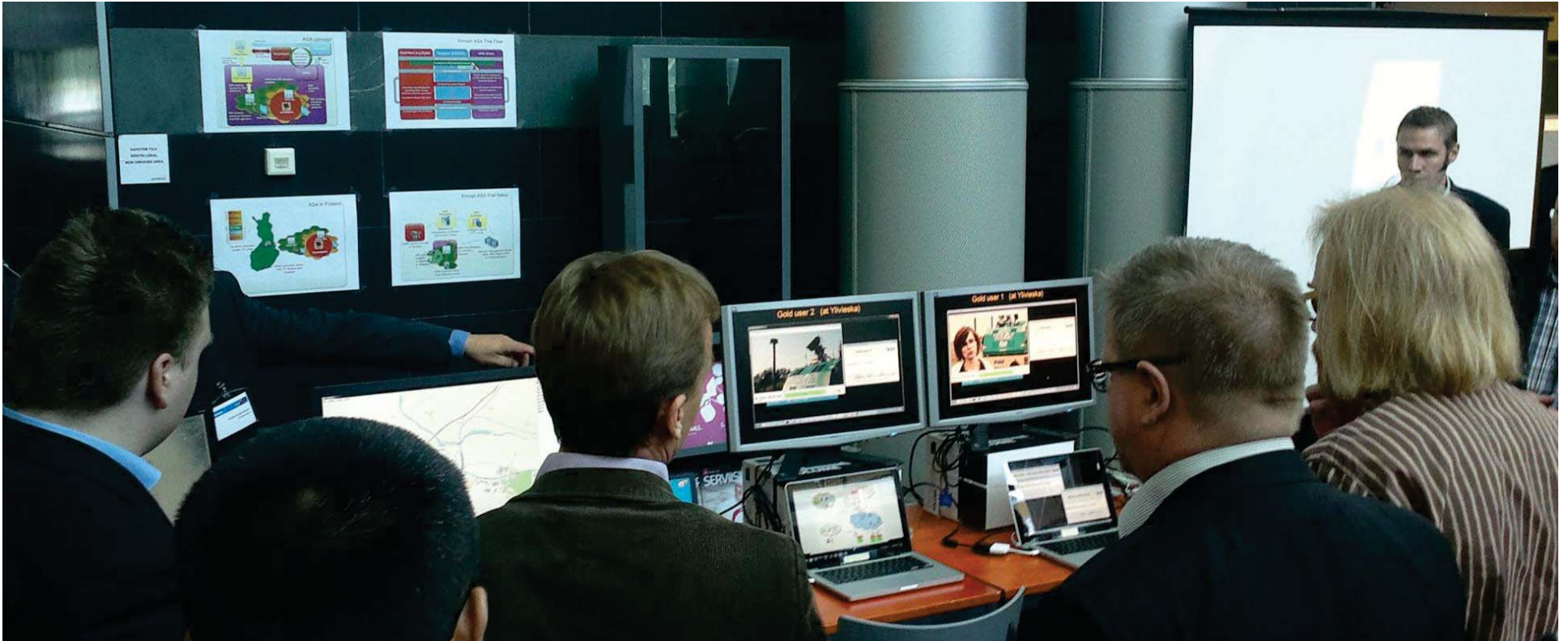


## LSA unlocks TD-LTE 2.3GHz band for operators in Europe

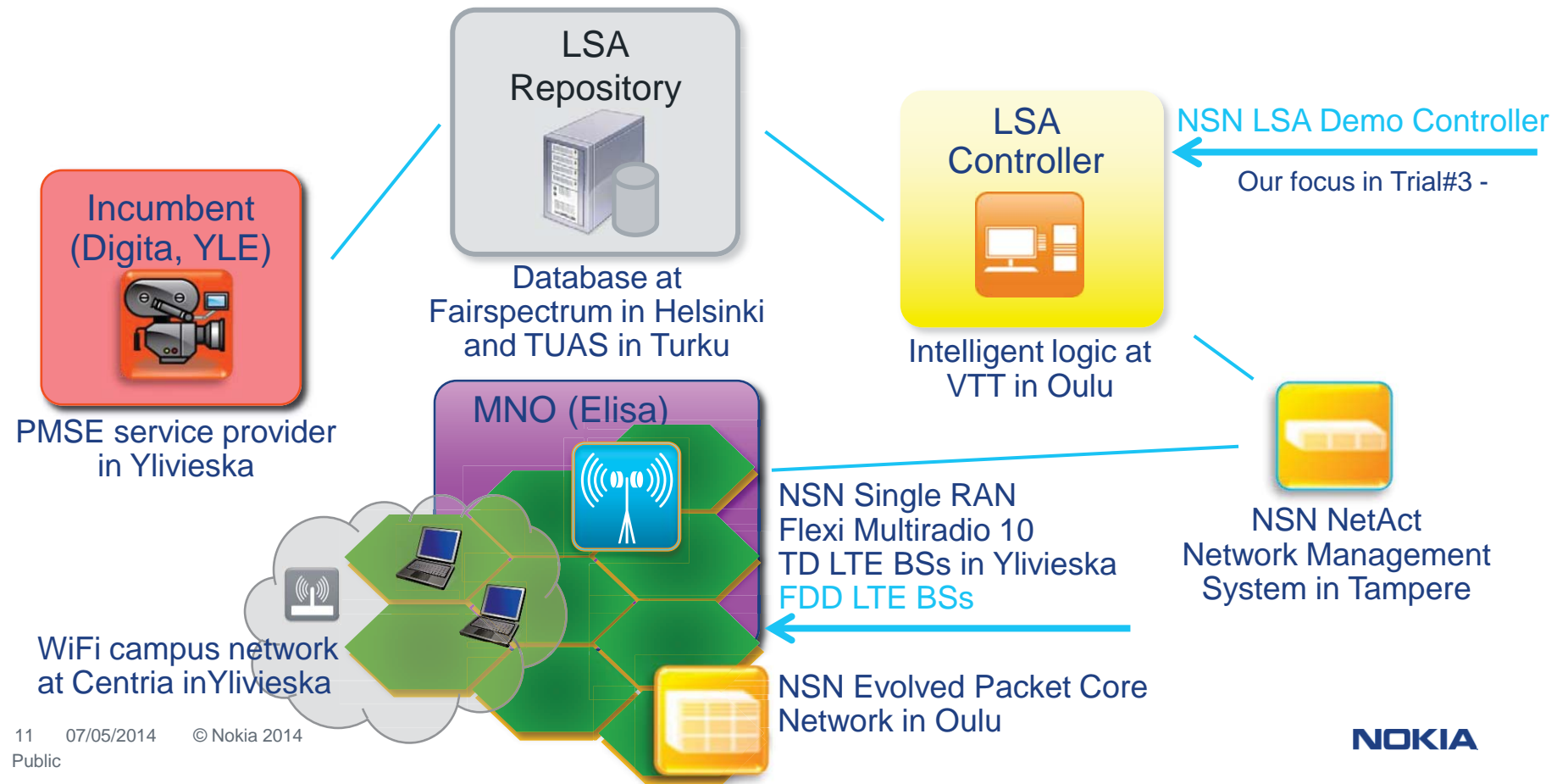
### LSA case in Finland



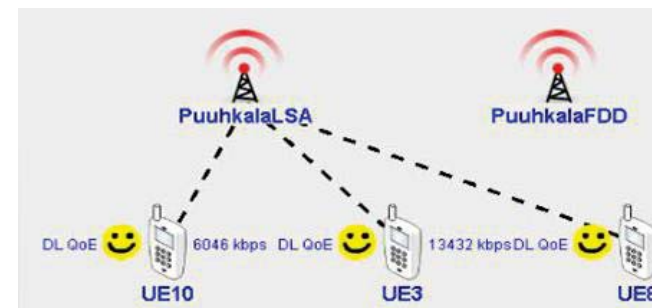
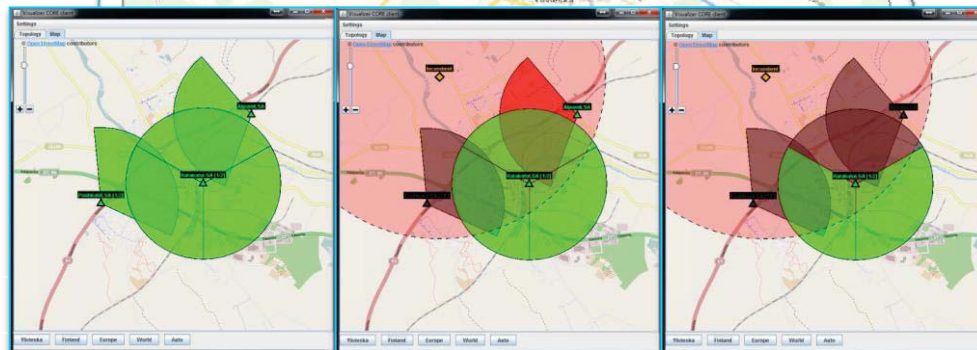
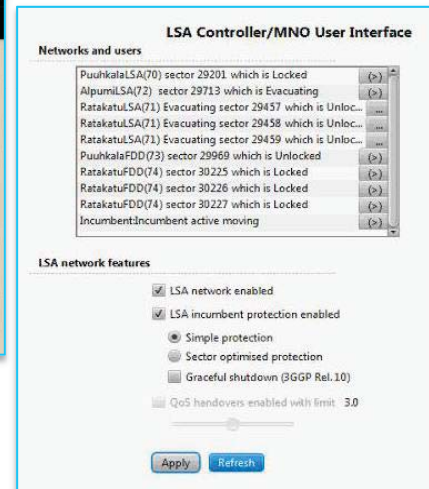
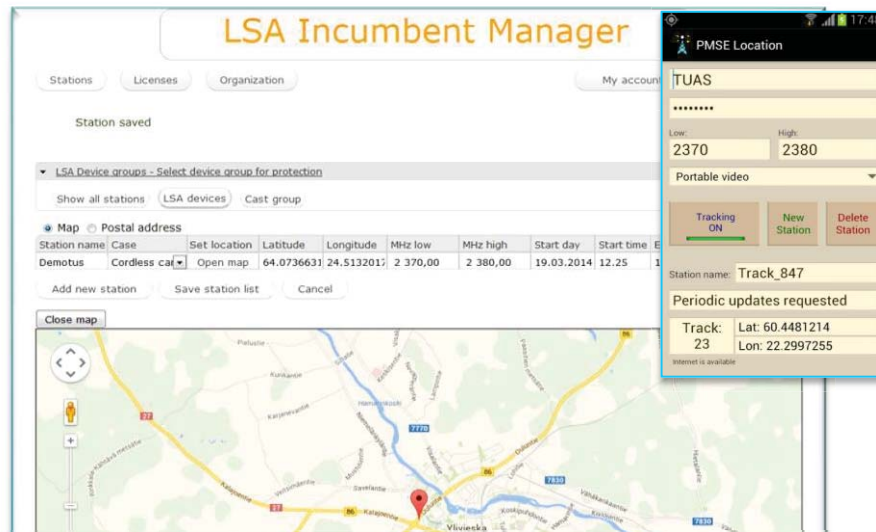
## World 1<sup>st</sup> on air LSA trial with Finnish ecosystem in 2013



## Trials built on NSN's core assets with full Finnish LSA ecosystem



# DySPAN'14 LSA live demo

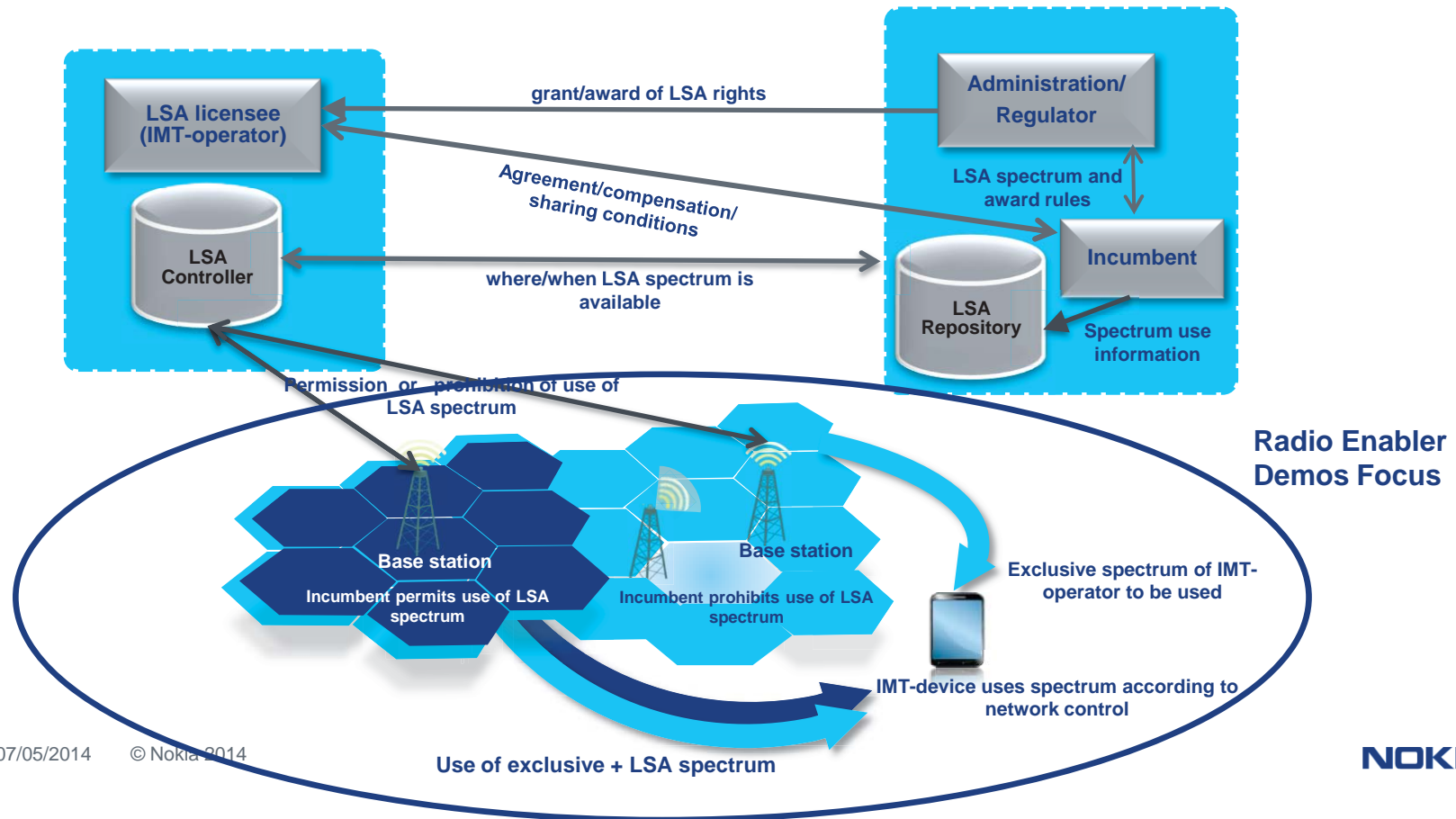


NOKIA

Public



## Example-Authorized/Licensed Shared Access (ASA/LSA)

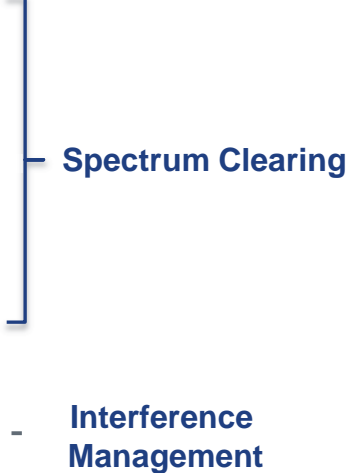


## Enabler Summary: RAN Only

### Assumptions

- Existing RAN feature set.
  - No LSA specific implementations
- Release 8 LTE standards compliant
- Simplified set-up
  - Emulated core network
  - Local operations & maintenance
  - Subset of possible use cases

### Enablers Demonstrated

- Immediate cell shutdown
  - Graceful cell shutdown
  - Cell barring
  - pMAX uplink power control -
- 
- Spectrum Clearing**
- Interference Management**

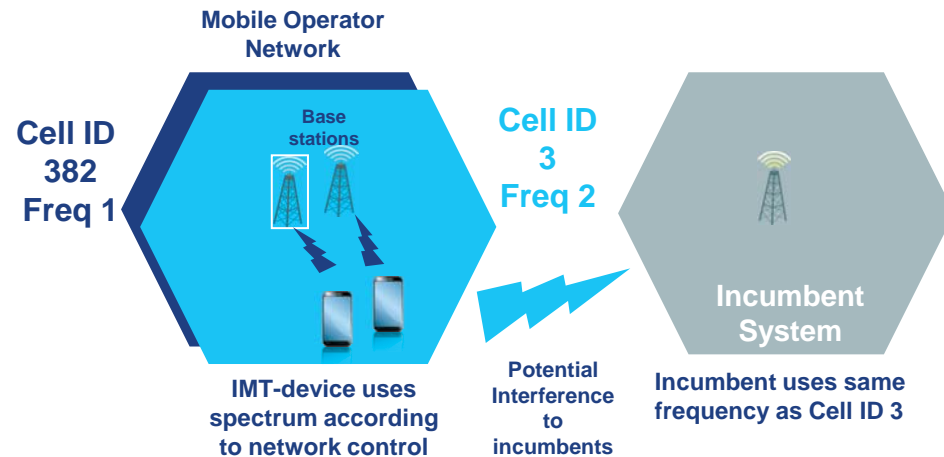
## Example Physical Scenario Emulated in Lab

### Two cells for Mobile Operator

- One cell is dedicated frequency
- One cell is shared frequency
- Overlapping cell coverage
- 2 UE devices in operator cells
- Used for all demo cases

### One cell for Incumbent

- Co-channel with operator shared frequency cell
- One UE
- Adjustable path loss to operator UE devices (AWS-3 scenario)
- Interference management demo case

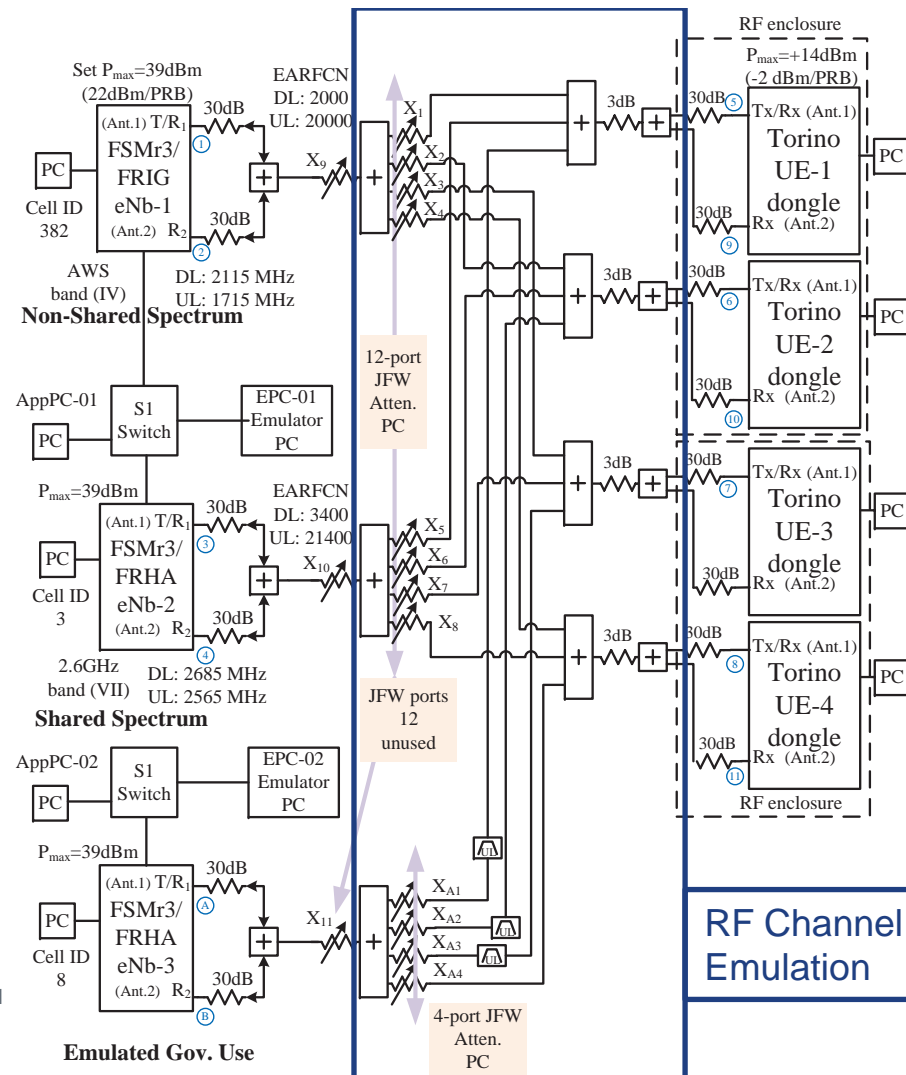


Cell ID 3 is shared frequency  
Cell ID 382 is not shared and overlaps cell ID 3 coverage

**Base Station  
Cell ID 382**

**Base Station  
Cell ID 3**

**Base Station  
Emulating  
Incumbent**

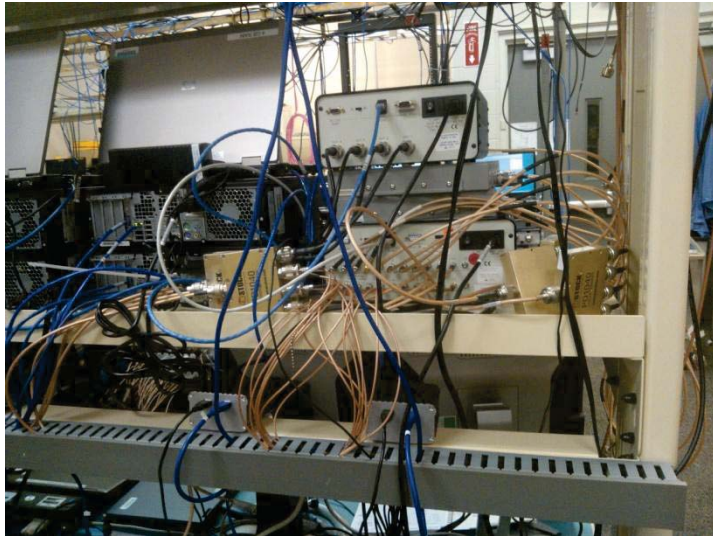


UEs 1 – 3 are cellular users. RF channel emulation settings determine preferred cells and path loss (distance to cell). They can interfere with uplink of Incumbent System if on that frequency.

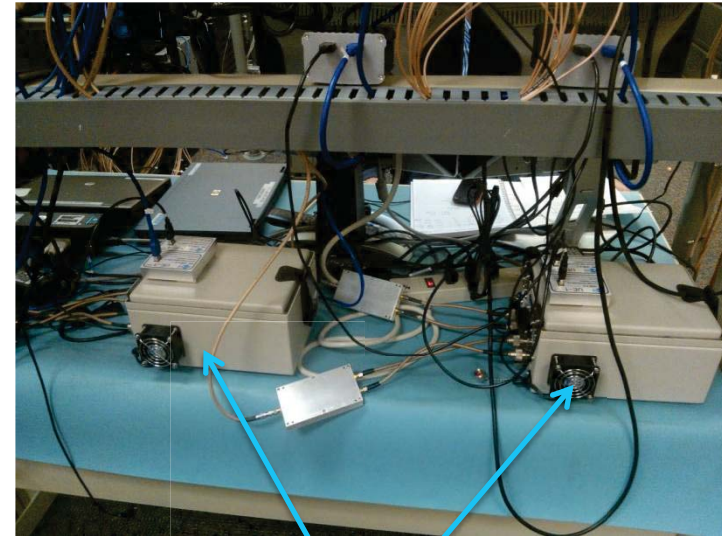
UE4 emulates incumbent user. Same frequency as Cell ID 3.



## In the Lab: Channel and UE Devices

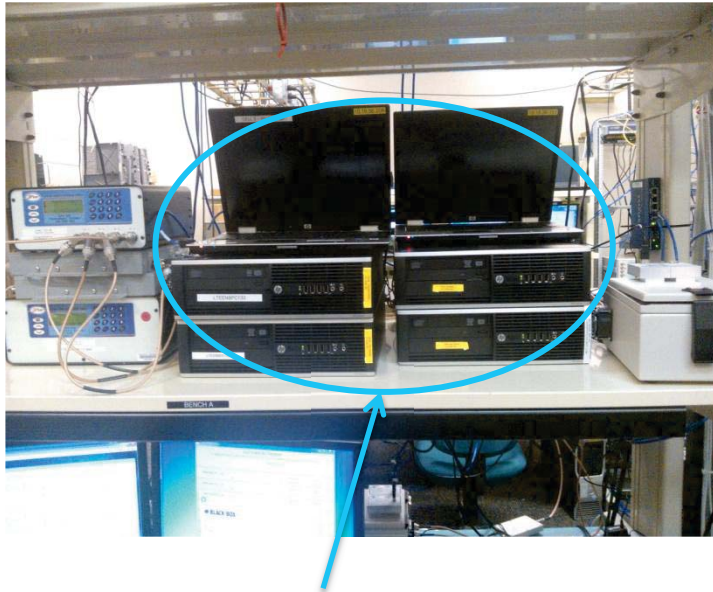


**Cables, splitters / summers and attenuators  
emulate the static RF channels**

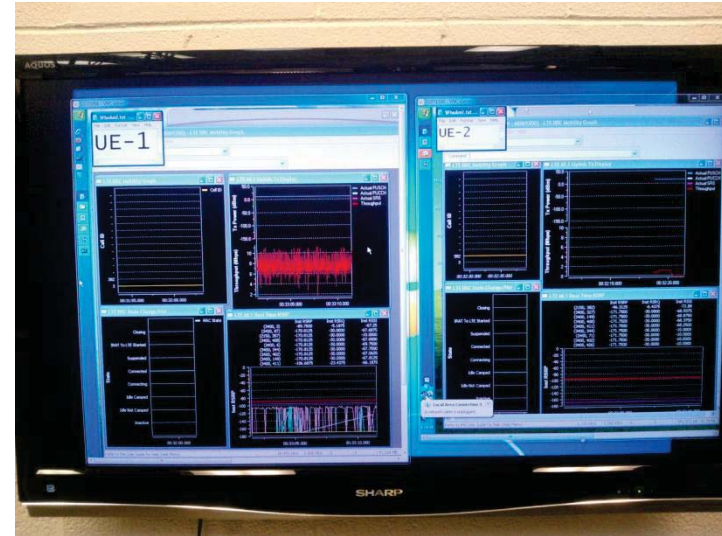


**UE USB Dongles in shielded RF enclosures**

## In the Lab: Network Emulation & Displays

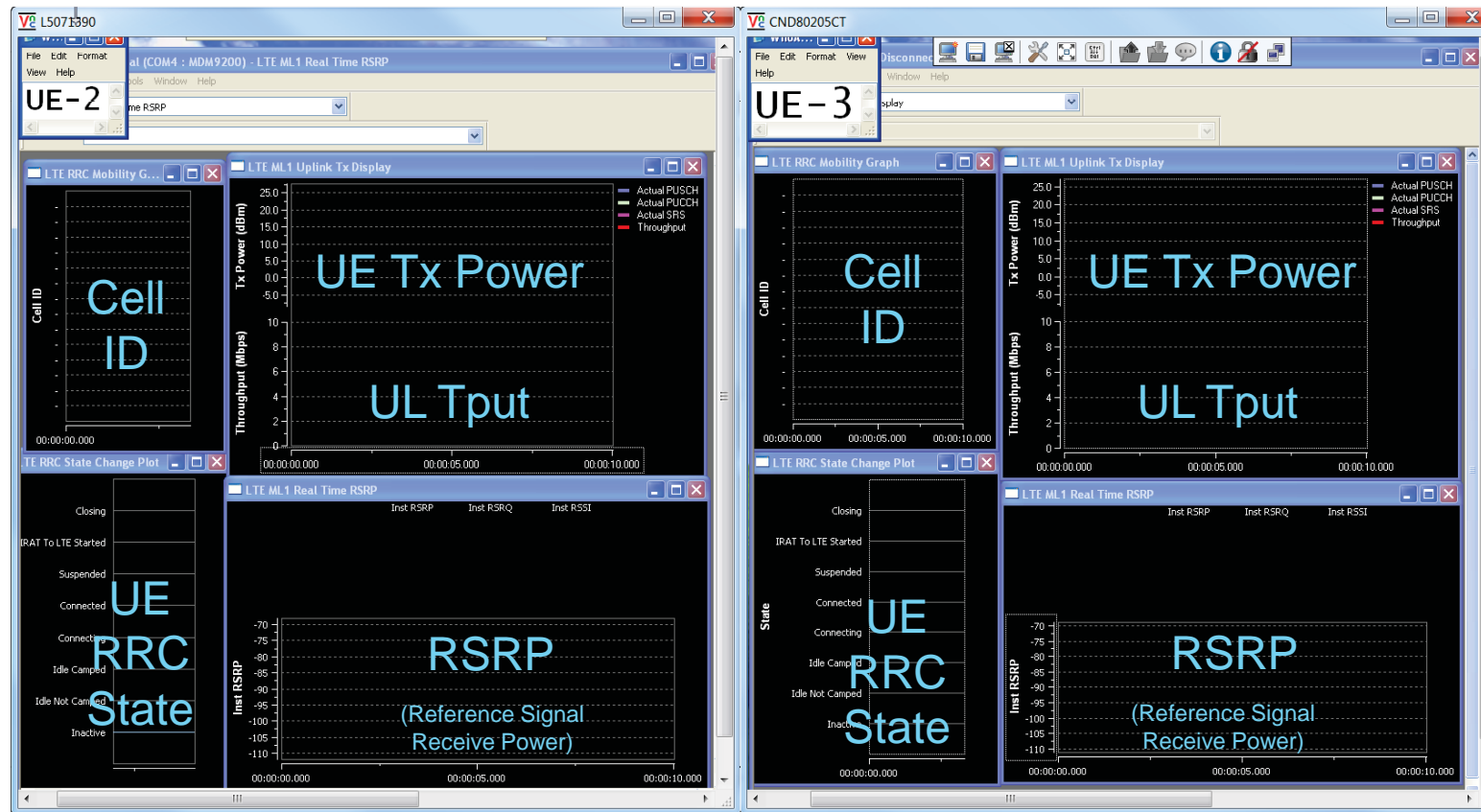


**EPC emulation, eNodeB and UE  
Application Control**



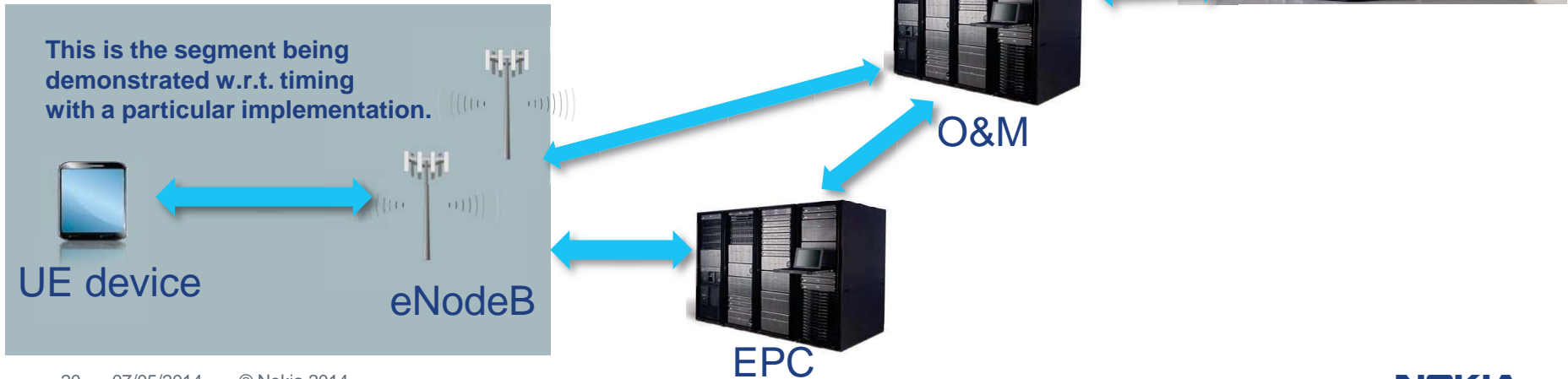
**UE device information display**

## UE Screen used for all tests / demos



## System Timing

- In general, the time it takes to act upon any commands to change the eNode B configuration depends on the response time of several subsystems (only logical control & management planes shown)
  - UE device
  - RAN (especially the eNodeB)
  - O&M and / or SON subsystem



## Cell Barring

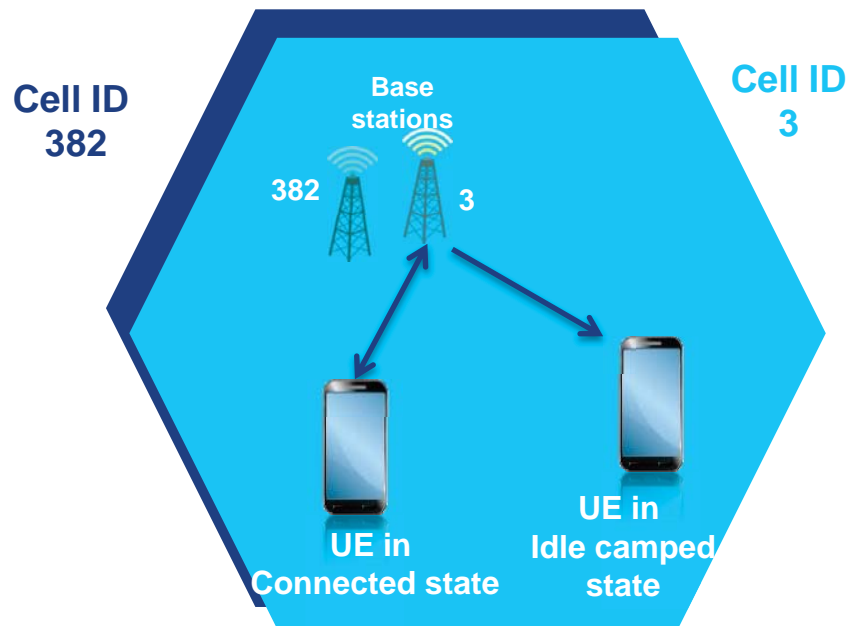
Prevents new UE attachments in affected cell

- Cell Barring is part of LTE standard
- Set CELL BAR flag = TRUE
- IDLE CAMPED UEs will immediately search for and attach to other available cells
- CONNECTED UEs are unaffected until transition to IDLE state, then reselect to another available cell
- New UE will not attach to barred cell

### Comments

- Cell barring assists cell clearing by:
  - Preventing a UE from attaching to cell
  - Forcing IDLE UE off of cell
- Used when anticipating need to clear a frequency and then used with other methods to clear the spectrum.

## Cell Barring



**Cell ID 3 is shared**  
**Cell ID 382 is not shared and overlaps cell ID 3 coverage**

## Cell Barring

Assists in clearing cell  
 Affected cell transmitter remains active  
 Broadcast channel indicates cell is barred

UE State	Start Cell	Process	End Cell	Notes
Connected	3	Idle Mode Reselection	382	Only after transition to idle state (session ends)
Idle Camped	3	Idle Mode Reselection	382	Immediate
Idle not camped	X	Idle Mode Reselection	382	Barred from entering shared cell

## Immediate Cell Shutdown

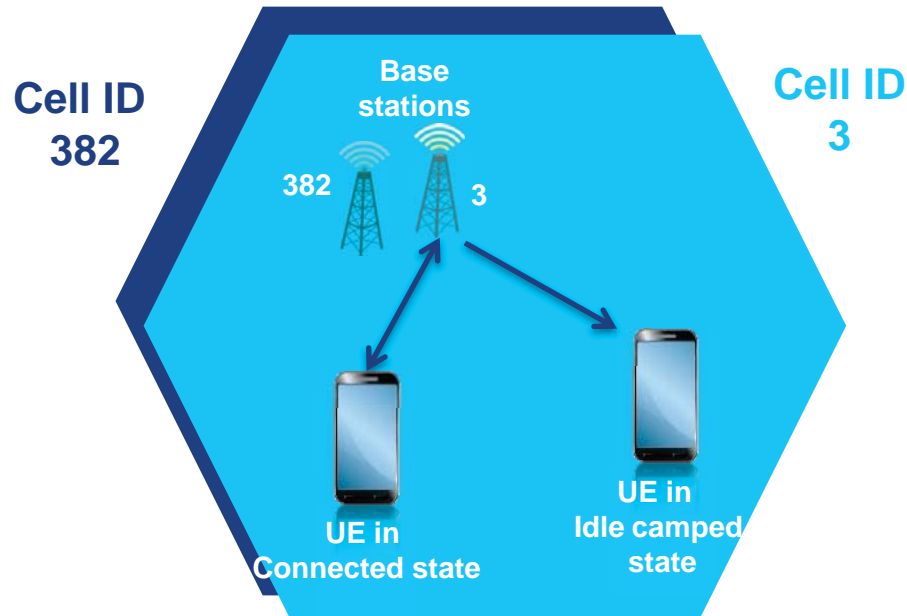
Clears shared spectrum as fast as possible

- Product feature; standards defined behavior
- Turns off shared frequency transceiver
- CONNECTED state UEs stop transmitting and search for a new cell.
- Idle state UEs search for new cell
- UE attaches to a new cell if available.  
Connected state is typically lost (application and network dependent).

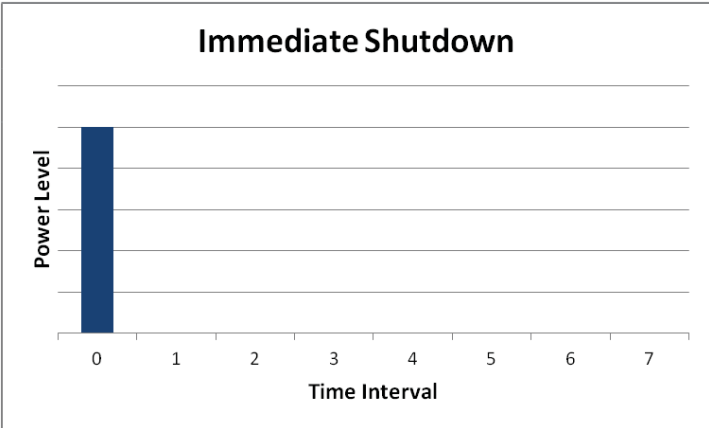
### Comments

- Ensures spectrum is cleared as fast as possible (in seconds )
- CONNECTED state is typically lost (application dependent)

# Immediate Cell Shutdown



Cell ID 3 is shared frequency  
 Cell ID 382 is not shared and overlaps cell ID 3 coverage



UE State	Start Cell	Process	End Cell	Notes
Connected	3	Idle Mode Reselection	382	Transmissions stop Session will drop
Idle camped	3	Idle Mode Reselection	382	



## Graceful Cell Shutdown

Clears spectrum after delay permitting some UE handovers

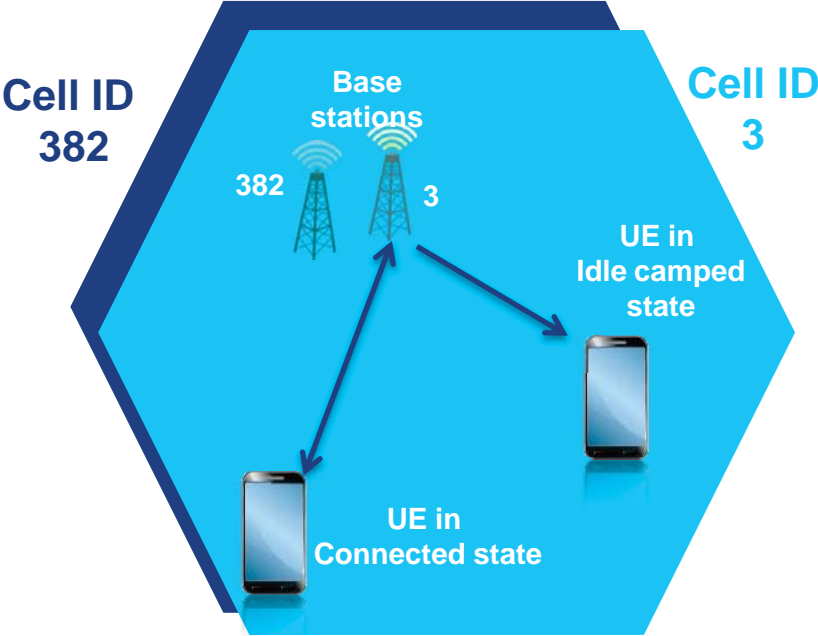
### Product Feature; standards defined behavior

- Shared frequency TX slowly ramps down transmission power
- Some UEs perform handover (dynamic range system design dependent). Connected state retained.
- Shared frequency cell turns off after ramp down complete
- Remaining UEs on shared frequency behave as in Immediate Cell Shutdown case and reselect to new cell

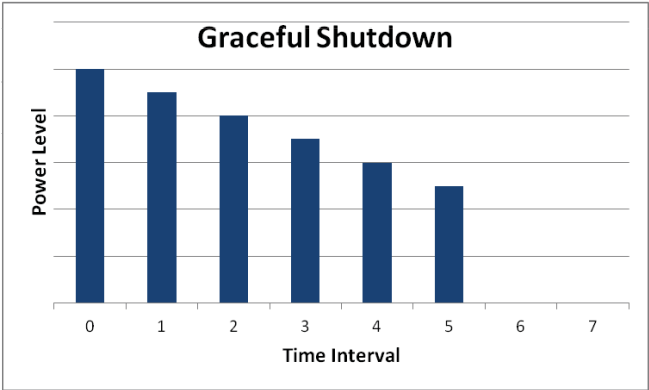
### Comments

- Only some UEs are expected to hand over before the cell shuts down. End state same as immediate shut down but with up to minutes to complete process.
- Transmitter dynamic range must exceed handover margin to enable handover... not guaranteed in real deployments
- Ramp down and delay must be set correctly for UE to detect change in power levels to initiate handover

# Graceful Cell Shutdown



Cell ID 3 is shared  
Cell ID 382 is not shared and overlaps cell ID 3 coverage



UE State	Start Cell	Process	End Cell	Notes
Connected	3	Handover	382	Dynamic Range > Handover Margin
Connected	3	Idle Mode Reselection	382	Dynamic Range < Handover Margin. Transmissions stop Session will drop
Idle camped	3	Idle Mode Reselection	382	

## pMAX Uplink Power Control

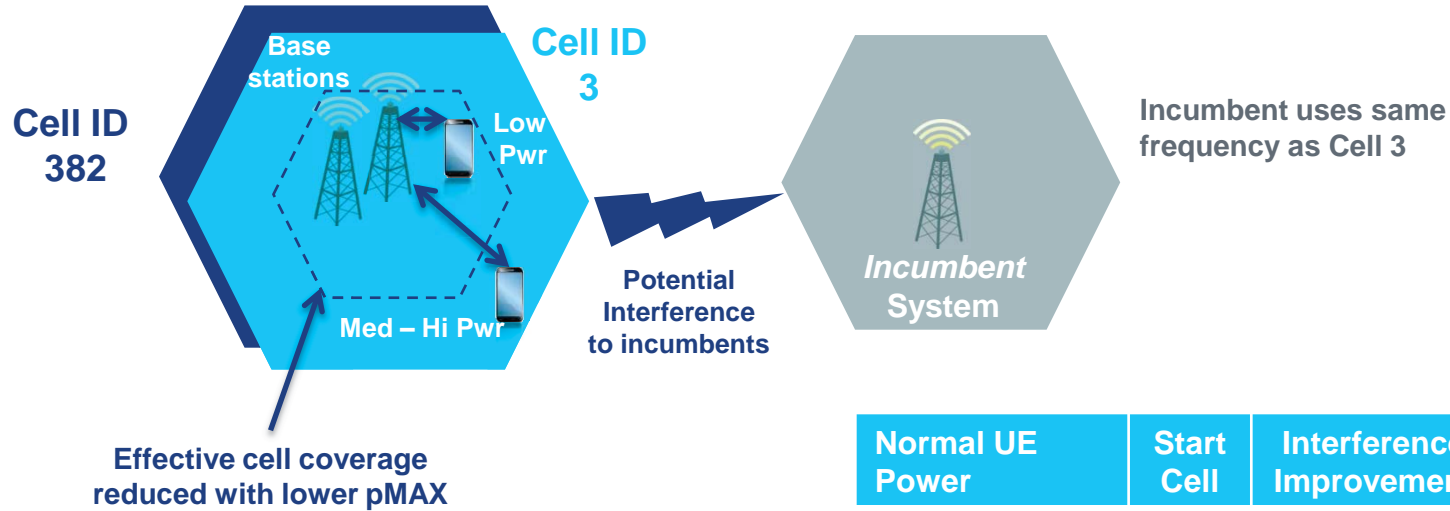
Manages uplink interference at expense of reduced cell coverage

- pMAX is part of LTE standard
- Set maximum limit on UE transmit power while permitting normal power control.
- All UEs will limit TX power to pMAX value potentially reducing interference to incumbent system
- If path loss is too high, handover may occur or UE connection drops and UE reselects to a new cell
- If path loss is too low, UE may already be at reduced power below pMAX limit resulting in no effect.

### Comments

- Reducing pMAX in shared spectrum cell effectively reduces cell coverage for the cell
- Not all UEs are affected equally. Net impact to aggregated interference will depend on UE distribution and path losses.

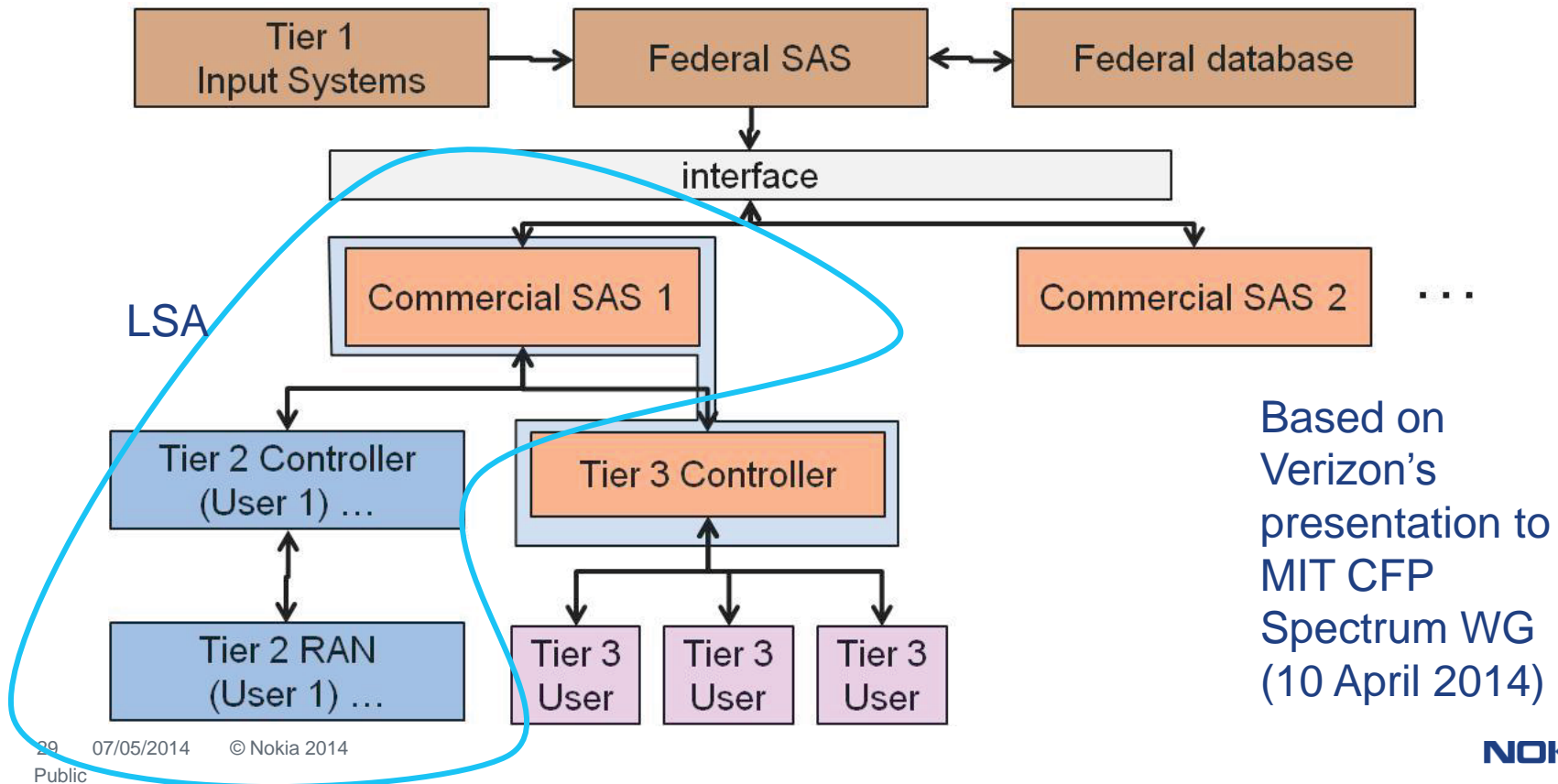
# pMAX Uplink Power Control



Cell ID 3 is shared  
Cell ID 382 is not shared and overlaps cell ID 3 coverage

Normal UE Power	Start Cell	Interference Improvement	Notes
Above new pMAX setting	3	Low – High depending on path loss to incumbent	Connection may hand over, or may drop and UE reselects to new cell if pMAX is too low for link conditions.
Near or below new pMAX setting	3	Low	

## Possible 3.5GHz SAS Architecture



## Conclusions

- **Current LTE standards and commercial equipment support enablers that serve as a foundation for an LSA solution**
- **Future LTE releases and products enable additional capability through such as features as carrier aggregation, load balancing and others**
- **Nokia is enabling the End-to-End LSA ecosystem.**

**Keep it simple !**

# NOKIA